**English translation of Japanese Patent Publication No. 2002-116807**
**Date of publication: April 19, 2002**

---

**Application Number: 2001-231305**
**Date of filing: July 31, 2001**

---

**Applicant: Toyota Central Res & Dev Lab Inc**

---

**Inventor: Teramoto Kazunari**
**Kuwano Yoshimasa**

[0009]

[Means for solving the Problems] To solve above-described problems, the present invention provides an integrated CAM system including a shape input means 1 for inputting a shape of a work piece; a machining planning means 2 for planning a machining method of the work piece; an NC data generating means 3 for generating NC data used for machining the work piece; an NC data verifying and editing means 4 for verifying and editing the NC data; and an NC data output means 5 for outputting the NC data, characterized in that the NC data is integrally generated based on shape data of a work piece as the work piece successively passes through these means, thereby attaining the above-described object. (Claim 1)

The machining planning means 2 for planning a machining method includes a process determining means (2-1) for determining processes in consideration of minimum machining cost, a machining condition determining means (2-2) for determining, for each determined process, tooling conditions represented by a combination of a tool and a holder in consideration of machining time, tool movement conditions suitable for the process, and cutting conditions suitable for the process, whereby the machining planning can be automated without requiring cogitation of an operator and can be completed with fewer number of man-hour and in a reduced lead time. Further, setting the cutting conditions in accordance

with the tooling is possible and the machining accuracy may be improved. (Claim 2)

The machining planning means includes a machining information database that contains a rule for determining a machining mode, a rule for determining cutting conditions and/or data for computing machining capabilities, thereby realizing an effective machine design using a machining database. (Claim 3)

The NC data generating means 3 for generating NC data includes a tool path computing means (3-1) for computing a tool path by taking into account tooling interference, uncut areas in a previous process, and overlap with a tool path of the previous process, or by taking into account uncut areas in the previous process and overlap with the tool path of the previous process, thereby obtaining an NC data based on an efficient tool path. (Claim 4)

The machining area data generated by the machining planning means is fed to the NC data generating means, and thus the tool path computing means in the NC data generating means can be devoid of a tool path computing function that takes interference in tooling into consideration. (Claim 5)

The NC data verifying and editing means for verifying and editing the NC data includes: a feed rate correcting means for verifying a cutting load and correcting a feed rate in accordance with the verified cutting load; and an NC data deleting and editing means for idle cutting portions for verifying meaningless idle

cutting portions and deleting NC data corresponding to the idle cutting portions, and editing the NC data around the idle cutting portions in consideration of the effects on machining, thereby achieving a stable machining with appropriate load and minimizing machining time by eliminating idle cutting portions. (Claim 6)

A dedicated interface is interposed between the machining planning means and the NC data generating means, and/or between the NC data generating means and the NC data verifying and editing means. With this structure, the machining planning means and the NC data generating means, or the NC data generating means and the NC data verifying and editing means that are conventionally separately provided can be integrated. (Claim 7)

The dedicated interface interposed between the machining planning means and the NC data generating means includes information regarding approaching and retracting. With this structure, the NC data can be generated that effectively utilizes information such as conditions regarding the path and speed of an approaching transfer from the machining start position or a temporary bypass position to an actually machined position and the path and speed of a retracting transfer from the actually machined position to the temporary bypass position or the machining terminate position. (Claim 8)

The dedicated interface interposed between the NC data generating means and the NC data verifying and editing means

includes information regarding conditions, containing simulation accuracy, under which simulation is implemented. With this structure, simulation conditions can be effectively provided to the NC data verifying and editing means. (Claim 9)

Any one of the NC data generating means, the NC data verifying and editing means, and the NC data outputting means includes an NC data converting means for converting NC data of a format particular to the NC data generating means into NC data of a predetermined format with which an NC machine can operate. Accordingly, the number of degrees of freedom in the place at which the function of converting the NC data is provided increases, thereby realizing a flexible system. (Claim 10)

The present invention also provides an integrated CAM system including: a shape input means 1 for inputting a shape of a work piece; a machining planning means 2 for planning a machining method of the work piece; an NC data generating means 3 for generating NC data used for machining the work piece; and an NC data output means 5 for outputting the NC data, in which the NC data is integrally generated based on shape data of a work piece as the work piece successively passes through these means, whereby NC data may be given to an existing NC machine having verifying and editing functions, or an operator may use a computer or the like to verify and edit data. (Claim 11)

The machining planning means 2 for planning a machining method

includes a process determining means (2-1) for determining processes in consideration of minimum machining cost, and a machining condition determining means (2-2) for determining, for each determined process, tooling conditions, tool movement conditions suitable for the process, and cutting conditions suitable for the process. With this structure, the machining planning can be automated without requiring cogitation of an operator and can be completed with fewer numbers of man-hour and in a reduced lead time. Further, setting the cutting conditions in accordance with the tooling is possible and the machining accuracy can be improved. (Claim 12)

The machining planning means includes a machining information database that contains a rule for determining a machining mode, a rule for determining cutting conditions and/or data for computing machining capabilities, thereby realizing an effective machine design using a machining database. (Claim 13)

The NC data generating means for generating NC data includes a tool path computing means (3-1) for computing a tool path by taking into account tooling interference, uncut areas in a previous process, and overlap with a tool path of the previous process, or by taking into account uncut areas in the previous process and overlap with the tool path of the previous process, thereby obtaining an NC data based on an efficient tool path. (Claim 14)

Machining area data generated by the machining planning means

is fed to the NC data generating means, and thus the tool path computing means in the NC data generating means can be devoid of a tool path computing function that takes interference in tooling into consideration. (Claim 15)

A dedicated interface is interposed between the machining planning means and the NC data generating means. With this structure, the machining planning means and the NC data generating means that are conventionally separately provided can be integrated. (Claim 16)

The dedicated interface interposed between the machining planning means and the NC data generating means includes information regarding approaching and retracting. With this structure, the NC data can be generated that effectively utilizes information such as conditions regarding the path and speed of an approaching transfer from the machining start position or a temporary bypass position to an actually machined position and the path and speed of a retracting transfer from the actually machined position to the temporary bypass position or the machining terminate position. (Claim 17)

Either of the NC data generating means or the NC data outputting means includes an NC data converting means for converting NC data of a format particular to the NC data generating means into NC data of a predetermined format with which an NC machine can operate. Accordingly, the number of degrees of freedom in the place

at which the function of converting the NC data is provided increases, thereby realizing a flexible system. (Claim 18)

According to the present invention, there is provided a method of integrally generating NC data, the method including: a step of inputting a shape of a work piece (a1); a step of planning a method of machining the work piece (a2); a step of generating NC data used for machining the work piece (a3); a step of verifying and editing the NC data (a4); and a step of outputting the NC data (a5), characterized in that the NC data of high quality is integrally generated based on shape data of the product as the product successively passes through these steps, thereby attaining the above-described object. (Claim 19)

The step of planning a method of machining (a2) includes the steps of: determining machining processes in consideration of minimum machining cost (a2-1); and determining, for each determined process, tooling conditions that take interference and rigidity into consideration, tool movement conditions suitable for the process, and cutting conditions suitable for the process (a2-2). In this method, the machining planning can be automated without requiring cogitation of an operator and can be completed with fewer numbers of man-hour and in a reduced lead time. Further, setting the cutting conditions in accordance with the tooling is possible and the machining accuracy can be improved. (Claim 20)

The step of planning a method of machining plans the method

of machining using a rule for determining machining mode, a rule for determining cutting conditions and/or data for computing machining capabilities, thereby realizing an effective machine design using a machining database. (Claim 21)

The step of generating NC data (a3) includes a step of computing a tool path (a3-1) which computes a tool path by considering tooling interference, uncut areas in a previous process, and overlap with a tool path of the previous process, or by considering uncut areas in the previous process and overlap with the tool path of the previous process, thereby obtaining an NC data based on an efficient tool path. (Claim 22)

Machining area data generated at the step of planning a method of machining (a2) is fed to the step of generating NC data, and thus the step of computing tool path in the step of generating NC data can be devoid of a tool path computing function that takes interference in tooling into consideration. (Claim 23)

The step of verifying and editing the NC data (a4) includes a step of verifying a cutting load and correcting a feed rate in accordance with the verified cutting load (a4-1), and a step of verifying meaningless idle cutting portions (a4-2) and deleting NC data corresponding to the idle cutting portions, and editing the NC data around the idle cutting portions in consideration of the effects on machining, thereby achieving a stable machining with appropriate load and minimizing machining time by eliminating idle

cutting portions. (Claim 24)

Any one of the step of generating NC data, the step of verifying and editing NC data, and the step of outputting NC data includes a step of converting NC data of a format particular to the NC data generating means into NC data of a predetermined format with which an NC machine can operate. Accordingly, the freedom in determining the procedure of converting the NC data can be increased and a flexible system can be realized. (Claim 25)

According to the present invention, there is also provided a method of integrally generating NC data including: a step of inputting a shape of a work piece (a1); a step of planning a method of machining the work piece (a2); a step of generating NC data used for machining the work piece (a3); and a step of outputting the NC data (a5), wherein the NC data of high quality is integrally generated based on shape data of a work piece as the work piece successively passes through these steps. With this structure, NC data may be given to an existing NC machine having verifying and editing functions, or an operator may use a computer or the like to verify and edit data. (Claim 26)

The step of planning a method of machining (a2) includes the steps of: determining machining processes in consideration of minimum machining cost (a2-1); and determining, for each determined process, tooling conditions that take interference and rigidity into consideration, tool movement conditions suitable for the

process, and cutting conditions suitable for the process (a2-2). In this method, the machining planning can be automated without requiring cogitation of an operator and can be completed with fewer numbers of man-hour and in a reduced lead time. Further, setting the cutting conditions in accordance with the tooling is possible and the machining accuracy can be improved. (Claim 27)

The step of planning a method of machining plans the method of machining using a rule for determining machining mode, a rule for determining cutting conditions and/or data for computing machining capabilities, thereby realizing an effective machine design using a machining database. (Claim 28)

The step of generating NC data includes a step of computing a tool path which computes a tool path by considering tooling interference, uncut areas in a previous process, and overlap with a tool path of the previous process, or by considering uncut areas in the previous process and overlap with the tool path of the previous process, thereby obtaining an NC data based on an efficient tool path. (Claim 29)

Machining area data generated in the step of planning a method of machining (a2) is fed to the step of generating NC data, and thus the step of computing a tool path in the step of generating NC data can be devoid of a tool path computing function that takes interference in tooling into consideration. (Claim 30)

Either of the step of generating NC data or the step of

outputting NC data includes a step of converting NC data of a format particular to the NC data generating means into NC data of a predetermined format with which an NC machine can operate. Accordingly, the freedom in determining the procedure of converting the NC data can be increased and a flexible system can be realized. (Claim 31)

According to the present invention, there is provided an integrated CAM system including: a shape input means 1 for inputting a shape of a work piece; a machining planning means 2 for planning a machining method of the work piece; an NC data generating means 3 for generating NC data used for machining the work piece; an NC data verifying and editing means 4 for verifying and editing the NC data; and an NC data output means 5 for outputting the verified and edited NC data, characterized in that, as the work piece successively passes through these means, the NC data is integrally generated based on shape data of the work piece by: feeding shape data of the work piece from the shape input means to the machining planning means; feeding machining processes of the work piece and machining conditions for each process from the machining planning means to the NC data generating means; feeding unedited NC data of the work piece from the NC data generating means to the NC data verifying and editing means; and feeding edited NC data used for actual machining of the work piece from the NC data verifying and editing means to the NC data output means. With this structure of

integrally generating the NC data based on shape data of a work piece as the work piece successively passes through these means, the above-described object can be attained. (Claim 32)

The present invention also provides an integrated CAM system including: a shape input means for inputting a shape of a work piece; a machining planning means for planning a machining method of the work piece; an NC data generating means for generating NC data used for machining the work piece; and an NC data output means for outputting the NC data, wherein the NC data is integrally generated based on shape data of a work piece by, as the work piece successively passes through these means: feeding shape data of the work piece from the shape input means to the machining planning means; feeding machining processes of the work piece and machining conditions for each process from the machining planning means to the NC data generating means; feeding the NC data of the work piece from the NC data generating means to the NC data output means. Accordingly, NC data may be given to an existing NC machine having verifying and editing functions, or an operator may use a computer or the like to verify and edit data. (Claim 33)

According to the present invention, there is provided a machining planning system that plans a method of machining a work piece for integrally generating NC data based on shape data of the work piece, the system including: a process determining means for determining processes in consideration of minimum machining cost;

and a machining condition determining means for determining, for each determined process, tooling conditions, tool movement conditions suitable for the process, and cutting conditions suitable for the process, thereby facilitating machining planning. (Claim 34)

According to the present invention, there is provided a machining planning system that plans a method of machining a work piece for integrally generating NC data based on shape data of the work piece, wherein, by using a rule for determining machining mode, a rule for determining cutting conditions and/or data for computing machining capabilities, a machining planning suitable for integral generation of NC data can be realized. (Claim 35)

The invention as claimed in claim 36 includes a process determining means for determining an optimum combination of a plurality of machining processes for machining a material into an intended product shape and a tool profile of a tool used for machining the material in each machining process; and a tool movement mode generating means for generating a tool movement mode of an apparatus for assisting a machine based on the machining process determined by the process determining means and the tool profile for each machining process.

[0010]

The invention as claimed in claim 45 is characterized in that a computer functions as: a process determining means for determining

an optimum combination of a plurality of machining processes for machining a material into an intended product shape and a tool profile of a tool used for machining the material in each machining process; and a tool movement mode generating means for generating a tool movement mode of an apparatus for assisting a machine based on the machining process determined by the process determining means and the tool profile for each machining process.

[0011]

According to the invention as claimed in claims 36 and 45, a simple rule can be established based on each machining process and each tool profile for machining a material. In this context, the term "product shape" includes the shape of a mold. A tool profile is preferably represented by a tool tip profile, tool diameter, and the like. A preferable apparatus for assisting a machine is a means for generating NC data, such as a CAM. Using the above-described simple rule, a tool movement mode of the apparatus for assisting the machine can be generated easily.

[0012]

The invention as claimed in claim 37 is characterized in that, in the invention according to claim 36, the tool movement mode generating means includes: a process type data storing means for storing process type data used for determining a machining mode in accordance with a combination of the machining process and the tool profile; a machining mode determining means for determining

a machining mode in accordance with the combination of the machining process determined by the process determining means and the tool profile for each machining process using the process type data stored in the process type data storing means; and a mode converting means for converting the machining mode determined by the machining mode determining means into a tool movement mode.

[0013]

The invention as claim in claim 45 is characterized in that, in the invention according to claim 46, the tool movement mode generating means functions as: a process type data storing means for storing process type data used for determining a machining mode in accordance with a combination of the machining process and the tool profile; a machining mode determining means for determining a machining mode in accordance with the combination of the machining process determined by the process determining means and the tool profile for each machining process using the process type data stored in the process type data storing means; and a mode converting means for converting the machining mode determined by the machining mode determining means into a tool movement mode.

[0014]

According to the invention as claimed in claims 37 and 46, a machining mode to be outputted for a combination of a machining process and a tool profile is described in the process type data stored in the process type data storing means. The machining

process is preferably represented by the order (number) of each process for machining a product shape. A tool profile is preferably represented by a tool tip profile, tool diameter, and the like. Thus, the process type data is formed by a simple rule of a machining mode in accordance with a combination of a machining process and a tool profile. Using the process type data, a machining mode corresponding to the combination of the machining process determined by the process determining means and a tool profile for each machining process, and a tool movement mode converted from the machining mode can be automatically determined.

[0015]

The invention as claimed in claim 38 is characterized in that, in the invention according to claim 37, the process type data storing means stores process type data used for determining a machining mode in accordance with a combination of a machining process and a tool profile of a tool having a ball-shaped tip profile.

[0016]

The invention as claimed in claim 47 is characterized in that, in the invention according to claim 46, the process type data storing means stores process type data used for determining a machining mode in accordance with a combination of a machining process and a tool profile of a tool having a ball-shaped tip profile.

[0017]

According to the invention as claimed in claims 38 and 47,

because the machining mode in accordance with a combination of a machining process and a tool profile of a tool having a ball-shaped tip profile is described in the process type data, a rule that includes a tool having a ball-shaped process tip profile and a machining process as a condition can be established. As a result, a practical machining mode for machining a three-dimensional curved surface and a tool movement mode converted from the machining mode can be generated.

[0018]

The invention as claimed in claim 39 is characterized in that, in the invention according to claim 37 or 38, the mode converting means converts the machining mode determined by the machining mode determining means into the tool movement mode using a conversion table representing correspondence between each machining mode and the tool movement mode.

[0019]

The invention as claimed in claim 48 is characterized in that, in the invention according to claim 46 or 47, the mode converting means converts the machining mode determined by the machining mode determining means into the tool movement mode using a conversion table representing correspondence between each machining mode and the tool movement mode.

[0020]

According to the invention as claimed in claims 39 and 48,

the machining mode determined by the machining mode determining means is converted into the tool movement mode using a conversion table representing correspondence between each machining mode and the tool movement mode. In this context, the term "tool movement mode" refers to a machining mode corresponding to the conventional CAM and, for example, an operating condition under which a tool of a machine is moved. Using the conversion table, data of general tool movement mode can be automatically generated from the machining mode.

[0021]

The invention as claimed in claim 40 includes: a process determining means for determining a plurality of machining processes for machining a material into an intended product shape, and machining capabilities of each machining process; a cutting conditions adjusting data storing means for storing, for each product type, cutting conditions adjusting data used for adjusting the machining capabilities by dividing the machining capabilities into predetermined directions at the time of cutting; and a cutting conditions generating means for reading out cutting conditions adjusting data corresponding to the product type to be machined from the cutting conditions adjusting data storing means and generating cutting conditions by dividing the machining capabilities of each machining process determined by the process determining means into the predetermined directions based on the

read cutting conditions adjusting data.

[0022]

The invention as claimed in claim 49 is characterized in that a computer functions as: a process determining means for determining a plurality of machining processes for machining a material into an intended product shape, and machining capabilities of each machining process; a cutting conditions adjusting data storing means for storing, for each product type, cutting conditions adjusting data used for adjusting the machining capabilities by dividing the machining capabilities into predetermined directions at the time of cutting; and a cutting conditions generating means for reading out cutting conditions adjusting data corresponding to the product type to be machined from the cutting conditions adjusting data storing means and generating cutting conditions by dividing the machining capabilities of each machining determined by the machining process determining means into the predetermined directions based on the read cutting conditions adjusting data.

[0023]

According to the invention as claimed in claims 40 and 49, cutting conditions adjusting data representing the manner in which the machining capabilities are divided into predetermined directions at the time of cutting is stored in the cutting conditions adjusting data stored in the cutting conditions adjusting data storing means. The cutting conditions adjusting data is previously

determined based on the know-how acquired at the machining site. By dividing the machining capabilities of each machining process determined by the process determining means into predetermined directions based on the cutting conditions adjusting data, cutting conditions can be automatically determined in accordance with the circumstances at the machining site by using the cutting conditions adjusting data incorporating the know-how acquired at the machining site.

[0024]

The invention as claimed in claim 41 is characterized in that, in the invention according to claim 40, the cutting conditions adjusting data storing means stores, for each product type, cutting conditions adjusting data for adjusting machining capabilities at the time of cutting by dividing the machining capabilities in a predetermined ratio for one or more stages with respect to a depth of cut in an axial direction of the tool, a depth of cut in a radial direction of the tool, and a feed rate; and the cutting conditions generating means generates cutting conditions by dividing, based on the read cutting conditions adjusting data, the machining capabilities of each machining process determined by the process determining means in a predetermined ratio with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate.

[0025]

The invention as claimed in claim 50 is characterized in that, in the invention according to claim 49, the cutting conditions adjusting data storing means stores, for each product type, cutting conditions adjusting data for adjusting machining capabilities at the time of cutting by dividing the machining capabilities in a predetermined ratio for one or more stages with respect to a depth of cut in an axial direction of the tool, a depth of cut in a radial direction of the tool, and a feed rate; and the cutting conditions generating means generates cutting conditions by dividing, based on the read cutting conditions adjusting data, the machining capabilities of each machining process determined by the process determining means in a predetermined ratio with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate.

[0026]

According to the invention as claimed in claims 41 and 50, the cutting conditions adjusting data further describes that the machining capabilities at the time of cutting are divided in a predetermined ratio for one or more stages with respect to the depth of cut in an axial direction of the tool, the depth of cut in a radial direction of the tool, and the feed rate. Note that, for some types of tools, a pick field amount may by used instead of the depth of cut in the radial direction. By dividing the machining capabilities in a predetermined ratio for one or more stages with

respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate, each cutting condition with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate can be automatically determined using the cutting conditions adjusting data based on the know-how acquired at the machining site.

[0027]

The invention as claimed in claim 42 is characterized in that, in the invention according to claim 41, the cutting conditions adjusting data storing means stores, for each product type, cutting conditions adjusting data that describes, for each stage, a lower limit value representing that each cutting condition with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate is saturated; and when at least one of the cutting conditions with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate is saturated in a predetermined stage, the cutting conditions generating means generates cutting conditions by dividing the machining capabilities in a predetermined ratio of a next stage with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate.

[0028]

The invention as claimed in claim 51 is characterized in that, in the invention according to claim 50, the cutting conditions adjusting data storing means stores, for each product type, cutting conditions adjusting data that describes, for each stage, a lower limit value representing that each cutting condition with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate is saturated; and when at least one of the cutting conditions with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate is saturated in a predetermined stage, the cutting conditions generating means generates cutting conditions by dividing the machining capabilities in a predetermined ratio of a next stage with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate.

[0029]

According to the invention as claimed in claims 42 and 51, the cutting conditions adjusting data further describes, for each stage, a lower limit value representing that each cutting condition with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate is saturated. When at least one of the cutting conditions with

respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate is saturated in a predetermined stage, the machining capabilities are divided in a predetermined ratio of a next stage with respect to the depth of cut in the axial direction of the tool, the depth of cut in the radial direction of the tool, and the feed rate. Here, the saturated cutting condition is preferably set to the lower limit value. As a result, when the machining capabilities vary as the machining process advances, machining capabilities are re-divided using the cutting conditions adjusting data based on the know-how acquired at the machining site, and thus efficient machining is realized.

[0030]

The invention as claimed in claim 43 includes: a machining coordinate system data storing means for storing, for each product type, machining coordination data including at least one of a machining start position representing an original position of a tool of a machine, a tool movement start position representing a position at which the tool begins to be moved, and a free movement area representing an area in which the tool can be freely moved; and a tool position data generating means for generating tool position data for specifying at least one of the machining start position representing the original position of the tool of the machine, the tool movement start position, and the free movement

area used for machining an intended mold shape by reading out, from the machining coordinate system data storing means, and utilizing the machining coordinate system data in accordance with the intended product type.

[0031]

The invention as claimed in claim 52 is characterized in that a computer functions as: a machining coordinate system data storing means for storing, for each product type, machining coordination data including at least one of a machining start position representing an original position of a tool of a machine, a tool movement start position representing a position at which the tool begins to be moved, and a free movement area representing an area in which the tool can be freely moved; and a tool position data generating means for generating tool position data for specifying at least one of the machining start position representing the original position of the tool of the machine, the tool movement start position, and the free movement area used for machining an intended mold shape by reading out, from the machining coordinate system data storing means, and utilizing the machining coordinate system data in accordance with the intended product type.

[0032]

According to the invention as claimed in claims 43 and 52, the machining coordinate system data describes at least one of the machining start position representing the original position of the

tool of the machine, the tool movement start position representing the position at which the tool begins to be moved, and the free movement area representing an area in which the tool can be freely moved. The machining start position is preferably set to the minimum or maximum value of each X, Y, and Z axis on a product reference surface. The free movement area is an area in which the tool can be freely and rapidly moved, and is preferably provided on one side of the X surface, Y surface, and Z surface. By generating tool position data that specifies at least one of the machining start position representing the original position of the tool of the machine, the tool movement start position, and the free movement area by using the coordination system data in accordance with the intended product type, pre-operations for controlling the machine can be automatically conducted.

[0033]

The invention as claimed in claim 44 includes: a tool operation information storing means for storing, for each product type and for each tool movement mode corresponding to an apparatus for assisting a machine, tool operation information including at least one of approach tool operation information representing conditions under which a tool approaches a cutting start position, and retraction tool operation information representing conditions under which a tool moves away from a cutting end position; and a tool operation information generating means for generating at least

one of the approach tool operation information and the retraction tool operation information, by reading out from the tool operation information storing means the tool operation information which corresponds to the product type to be machined and the tool movement mode used for machining the product type, and generating at least one of the approach tool operation information and the retraction tool operation information using the read tool operation information.

[0034]

The invention as claimed in claim 53 is characterized in that a computer functions as: a tool operation information storing means for storing, for each product type and for each tool movement mode corresponding to an apparatus for assisting a machine, tool operation information including at least one of approach tool operation information representing conditions under which a tool approaches a cutting start position, and retraction tool operation information representing conditions under which a tool moves away from a cutting end position; and a tool operation information generating means for generating at least one of the approach tool operation information and the retraction tool operation information, by reading out from the tool operation information storing means the tool operation information which corresponds to the product type to be machined and the tool movement mode used for machining the product type, and generating at least one of the approach tool

operation information and the retraction tool operation information using the read tool operation information.

[0035]

According to the invention as claimed in claims 44 and 53, the tool operation information exists for each product type and for each tool movement mode in accordance with the apparatus for assisting the machine. The tool operation information further includes at least one of the approach tool operation information representing conditions under which the tool approaches the cutting start position, and the retraction tool operation information representing conditions under which the tool moves away from the cutting end position. The approach tool operation information is preferably represented by a value representing an operation of the tool moving toward the initial cutting command position, i.e., the distance that the tool is rapidly moved upward from the initial cutting command position, and a value representing the position above the initial cutting command position at which the tool begins approach operation. The retraction tool operation information is preferably represented by a value representing the distance above the last cutting command position at which the tool is rapidly moved upward. Then, at least one of the approach tool operation information and the retraction tool operation information of the tool movement mode used for machining the product shape is generated using the tool operation information in accordance with the intended

product type and the tool movement mode for machining the product type. Because the tool operation information at the time of approaching and retracting is generated in this manner, troubles such as breakage of the tool caused during machining can be prevented and pre-operations for control of the machine can be automatically conducted.